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ABSTRACT

A persistent problem for instructional designers has been deciding exactly what to do. To be of value in the development process, an instructional design needs to be developed with consideration of the kinds of objectives to be achieved, the specific activities used to teach the objectives, and the order or sequence in which the learning activities occur. Instructional designers need prescriptive advice on teaching a full slate of human behaviors that range from memorizing facts to solving problems, and instructional theory can address these issues of what is being taught and how to teach it effectively. Two theories, Gagne's and Merrill's, both prescribe a system of classifying learning outcomes with a corresponding set of instructional strategies or steps. The prescriptive nature of both theories and their complementary macro-micro approaches to designing instruction make them adaptable to computerization. The Instructional Designer is a software package for use by instructional designers which incorporates these two theories. In order to examine the effectiveness of the Designer, a study was completed with students in a graduate class in instructional design. The conclusion drawn from this tryout with the Designer as a tool in the hands of novice developers is that the program helps to promote the creation of instruction with a high probability of being successful with students because the design incorporates events that instructional theory suggests are critical for learning. The text is supplemented by nine figures and a sample design is appended. (7 references) (EW)

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Incorporating Instructional Theory In Instructional Design

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Incorporating Instructional Theory In Instructional Design

A persistent problem for instructional developers in the design of materials is deciding exactly what to do. The term instructional design has nebulous meanings for many. What are instructional developers doing when they are designing instruction? A design needs to be more than a vague idea about "using a game format" or following a "discovery approach". Such declarations or decisions may provide some overall focus for designing instruction but completely fail to provide specifications for the detailed structure of the instruction to be produced.

To be of value in the development process, an instructional design needs to be a plan that provides specific information about activities that will be used to teach learners. As such, an instructional design for achieving the goals or objectives of instruction needs to deal with --

- the kinds of objectives to be achieved
- the specific activities used to teach objectives
- the order or sequence in which learning activities occur

Role of Theory in Instructional Design

Virtually every instructional development model has a step between analysis and production that deals with the design of the instruction. This step is called "design", "specify learning events", "design system", "design instruction", and "develop instructional strategy" in various development models (cf., Gustafson, 1981). Although the names differ, the intent of this step in the development process is clear -- to set forth a specific strategy or plan to use in achieving objectives.

The model shown in Figure 1 contains features included in most instructional development models. For developers to carry out the steps in the model, it is common to call on various sources of information, knowledge, or theory. For example, a developer may use ideas from Mager (1984) in carrying out the task of identifying particular objectives. Or, the work of Rossett (1982) may be used to provide direction for clarifying goals. Many developers are not so sure about where to find help in carrying out the step of designing instruction (called *developing instructional strategy* in this model)?

What is needed by an instructional developer for carrying out the instructional design step in the model is prescriptive advice on teaching a full slate of human behaviors that range from memorizing facts to solving problems (Gagné, Briggs, & Wager, 1988). This wide range of skills requires that an instructional developer is able to define the kind of objective to be learned and devise a strategy that is effective in teaching the objective. The role of instructional theory is to address these issues of what is being taught and how to teach it effectively.

Complementary Theories of Instruction

Two instructional theorists -- Gagné (1985) and Merrill (1983) -- have provided specific directions on how to design instruction aimed at particular kinds of outcomes. Their theories deal with --

- matching instruction to specific kinds of behavior
- specifying instructional events to be included in instruction
- sequencing events in a lesson

The theories of Gagné and Merrill are prescriptive in the sense that they guide developers in what to do and when to do it. And they provide specific strategies for teaching discriminations, facts, concepts, rules, principles, and problem solving.

Instructional theories address questions of what to teach and how to teach it effectively by prescribing a system of classifying learning outcomes with a corresponding set of instructional strategies or steps. Gagné's and Merrill's theories deal with each of these points in different but complementary ways.

Gagné's Theory. Gagné describes five categories of learning outcomes (See Figure 2). Categories 4 and 5 correspond to affective and psychomotor skills, respectively, while categories 1 to 3 are related to cognitive skills which are separated into those that require simple recall (verbal information), those that require more complex thinking (intellectual skills), and those that lead to strategies for learning how to learn (cognitive strategies). The intellectual skills are further classified into 5 subcategories which range from the basic skill of recognizing similarities and differences (discriminations) to skills in the application of learned rules for problem solving. For each of these categories, particular conditions of learning are needed and, thus, a particular instructional strategy is required.

The set of instructional steps in Gagné's theory consists of 9 events of instruction (See Figure 3). These events correspond to internal mental processes which are required for learning. At this level they do not address differences among objective types and their instruction. The inclusion of these external events in instruction increases the chances of accomplishing objectives and of learning taking place.

Events 1 to 3 prepare the learner for the instruction. Attention is focused on what is to be learned, expectations are clarified, and previous knowledge is recalled to provide linkage between old and new learning. Events 4 and 5 start the actual teaching-learning process through the presentation of materials to be learned. Events 6 and 7 enhance learning by providing practice and feedback. In this particular portion of the instruction, control is gradually shifted from the teacher to the learner. The last two events of instruction consist of the assessment of the learning that took place and provision of steps for the retention of what was learned and

transfer of learning to other similar applications. The strategies used in Events 4 to 9 differ from one kind of objective to another and are critical to the effectiveness of the instruction and learning itself.

Merrill's Component Display Theory (CDT). As an instructional theory, CDT has detailed procedures for classifying instructional objectives and selecting corresponding instructional strategies. To classify instructional objectives, a performance/content matrix is used (See Figure 4). Performance has three levels -- remember, use, and find -- representing a simple-to-complex order of intellectual skills. The first level, remember, is subclassified into remembering a generality (recalling a main idea) and remembering an instance (recalling a particular example of a main idea). Remembering may also either be of the verbatim or paraphrase type. The content axis classifies subject matter into facts, concepts, procedures, and principles.

According to component display theory, instruction takes place in 3 phases -- presentation, practice, and performance -- and depending on the type of outcome desired, it prescribes the appropriate strategy through a combination of primary and secondary presentations. Briefly stated, in a primary presentation, a generality or an instance may be presented through an expository (telling) or an inquisitory (asking) method. Secondary presentations, on the other hand, are supplementary strategies in the form of feedback, mathemagenics, and representations which will enhance learning. For every particular set of outcomes and for every phase of instruction, a specific combination of primary and secondary presentations is prescribed by the theory. For instance, the outcome *to construct a histogram of scores* is classified as a *use-procedure* type. For this type of outcome, CDT prescribes the following strategy:

Presentations

Phase	Primary	Secondary
Presentation:	EG,Eegs	For EG: EG'h, EG'p,EG'r For Eegs: Eeg'h,Eeg'r
Practice:	Ieg.N	Ieg'r,FB'h
Performance:	Ieg.N	None

Simply stated, the instruction starts in an expository fashion by giving the rules (steps) in constructing a histogram (EG) and then a number of sample exercises are given (Eegs). In presenting the rules, the instructor enhances instruction through mathemagenic help (EG'h), attention to prerequisites (EG'p), and the use of representations (EG'r). For practice, sets of new data are given (Ieg.N) and learners are asked to construct histograms, guided by feedback (FB'h). Learner performance is

evaluated by providing still more new sets of data (legs.N) and learners construct histograms independently.

The total number of strategies prescribed by CDT corresponds to the number of cells found in the performance/content matrix (see Figure 5). The task for the designer in using Merrill's component display theory is to classify the objective of the instruction and then follow the prescribed set of expository (telling) and inquisitory (asking) events for that kind of outcome during the presentation, practice, and performance phases of instruction. Further, the expository and inquisitory events need to be differentiated according to the type of content --whether a fact, concept, procedure, or principle.

Interrelationship between Gagné's and Merrill's theories: Figure 6 summarizes the two theories as they relate to instructional design. It should be noted that CDT provides a more detailed level of addressing the questions on hand. However, this does not imply that the two theories are not interrelated. On the contrary, if Gagné's system of objective classification is woven into the performance/content matrix of outcomes, the 3 cognitive levels (verbal information, intellectual skills, cognitive strategies) have their equivalent in the matrix (See Figure 7). Except for attitudes and motor skills, the CDT matrix parallels to a considerable extent the classification system prescribed by Gagné. Thus the two theories may be considered congruent in their classification of learning outcomes and differ only in their forms of presentation.

As for strategies, Gagné's theory provides the macro-strategy, that is, the steps in the overall design of instruction. Further, it provides explicit direction on the introduction to a lesson when learners attention is gained, purposes are communicated, and prerequisites are recalled. CDT complements these steps specifically (from the 4th event up to the 9th), by prescribing micro-strategies or instructional methods for the presentation, practice, and performance phases of instruction. That means if instruction is desired, the events of instruction may be considered as the major steps to be included in the design and CDT provides strategies made up of specific combinations of primary and secondary presentations that change depending on the type of learning outcome desired. The merging of the two theories results in the 6-step model shown in Figure 8.

The Instructional Designer

The prescriptive nature of Gagné's and Merrill's theories and their complementary macro-micro approaches to designing instruction make them adaptable to computerization, that is, the production of software for use by instructional developers in preparing instructional designs incorporating these two theories.

The Software. The Instructional Designer (or the Designer) was developed to promote validity and facility in designing instructional materials. Validity is based on the assumption that the design will provide effective instruction because it is derived from established theories of instruction. In other words, designing occurs with the

developer knowing that the instructional theories are implicityly woven in the design. There is, likewise, facility in designing because the computer takes care of the design format and instructional strategies while the user inputs the lesson parts in particular. In addition to these, the Designer contains help functions in the form of definitions, discussions, and examples for each of the steps in the instruction.

Using the Designer. Designing instruction with the Designer starts with an input of the instructional outcome and its classification. The computer responds by matching the type of outcome with the appropriate instructional strategies or steps as specified by the theory for that kind of outcome. If the user gives a wrong classification of an objective, the set of strategies provided will not suit the lesson being designed. Thus, it is critical that the user has skill in classifying objectives correctly.

Following the acceptance and classification of the objective, the screens that will accept the user's specifications for each step are displayed in sequence (See Figure 9). This part of designing is highly interactive and provides enough flexibility to put into play the creativity and expertise of a developer which could have been gained from years of experience. For novice developers, the Designer provides necessary explanations and examples to carry out a complete lesson design. First the user is prompted to provide information on how attention will be gained, how objectives are made clear, and how prerequisite knowledge will be recalled. Following this, the user is further prompted to enter information on the presentation, practice, and performance phases of the lesson appropriate for the kind of objective specified. In all these cases the Designer provides definitions, descriptions, and examples of the kinds of information to be entered.

The last screen seen by the developer shows whether information for all the instructional events for this objective have been entered. The developer then directs the completed design to a printer or to disk storage. The output or result from using the Designer is a printed copy of the design (See the Appendix for a sample design) which the developer can use as a guide in carrying out the instruction.

Tryouts With the Instructional Designer

The utility of an instructional design tool can be assessed by placing it in the hands of novice or experienced instructional developers to determine if they can use the tool and if using it results in better products. The ultimate test of the value of any tool would be whether learners achieved more or learned more efficiently when using instructional programs produced with its aid. But this ultimate test is difficult to arrange because of the time, control, and resources required. An alternative is to examine the apparent quality of instructional plans or materials with an eye to their likely effectiveness when used.

In order to examine the effectiveness of the Designer a study was completed with students in a graduate class in instructional design. At the time the study was done, the students had studied instructional development models and had worked with the instructional theories of Gagné. They had also completed such topics as goal analysis, writing objectives, and developing criterion tests.

The eleven students were given one of two tasks and told to "prepare an instructional plan for teaching this objective." All students were first given this task to complete as a paper and pencil exercise and second as a computer exercise using the Instructional Designer. Half the students were given one task and half the other on each occassion (paper/pencil or computer design). The products produced by students were either the written or printed designs that resulted from their labors. These designs were then examined to identify what these novice instructional developers included in their designs and what they chose to ignore.

- Instructional developers following a paper/pencil procedure to produce a design fail to include activities associated with several of the events of instruction.

  gaining attention -- usually missing, no effort at focusing learners on the task is used to start a lesson.

  presenting objectives -- only rarely are learners told explicitly or implicitly what the objectives are.

  recall prerequisites -- sometimes developers will describe a pretest on prerequisites but usually nothing is done to bring pertinent prerequisites into the lesson.

  presentation -- presentations about the task such as definitions or steps in the process to be learned are not usually provided. Instead developers tend to lead students almost directly into practice with feedback.

- Instructional designers using the Designer tend to incorporate the full complement of instructional events regarded as important. Attention is gained, objectives are made clear, and prerequisites are recalled. Further, they present stimulus materials appropriate to the task and as a prelude to practice and feedback.

- Virtually all designs (with and without the aid of the Designer) include practice and feedback. Instructional developers know that some kind of practice with the task to be learned is appropriate.

The conclusion drawn from this tryout with the Designer as a tool in the hands of novice developers is that the program helps pomote the creation of instruction with a high probability of being successful with learners. Success is predicted because the design incorporates events that instructional theory suggests are critical for learning.

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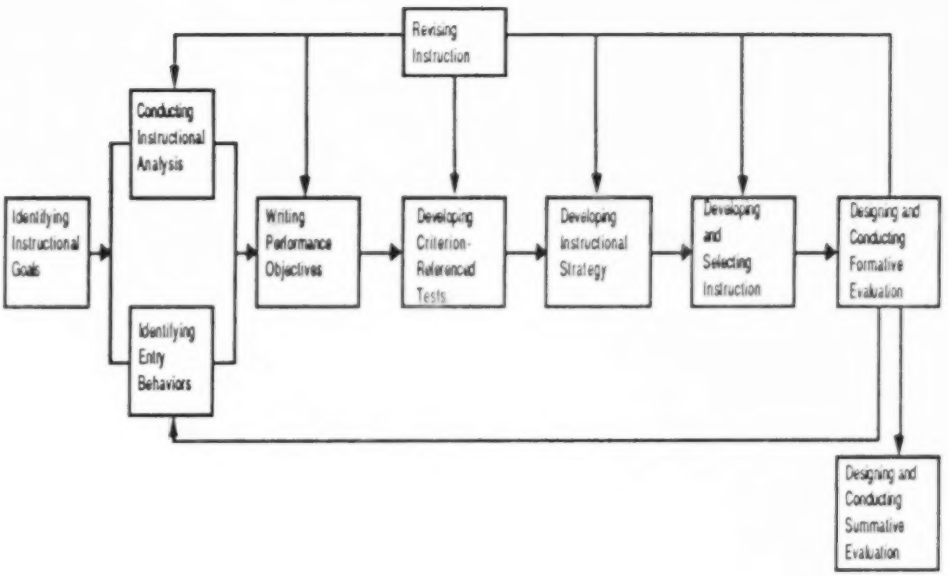

Figure 1. An instructional development model by Dick & Carey (1985).

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1. Intellectual Skills

    a. discriminations
    b. concerete concepts
    c. defined concepts
    d. rules
    e. high-order rules (problem solving)

2. Verbal Information

3. Cognitive Strategies

4. Motor Skills

5. Attitudes

Figure 2. Gagné's five categories of learning outcomes.

1. Gaining attention

2. Informing the learner of the lesson objective

3. Stimulating recall of prior learning

4. Presenting the stimulus material with distinctive features

5. Providing learning guidance

6. Eliciting performance

7. Providing informative feedback

8. Assessing performance

9. Enhancing retention and learning transfer

Figure 3. Gagné's nine events of instruction.

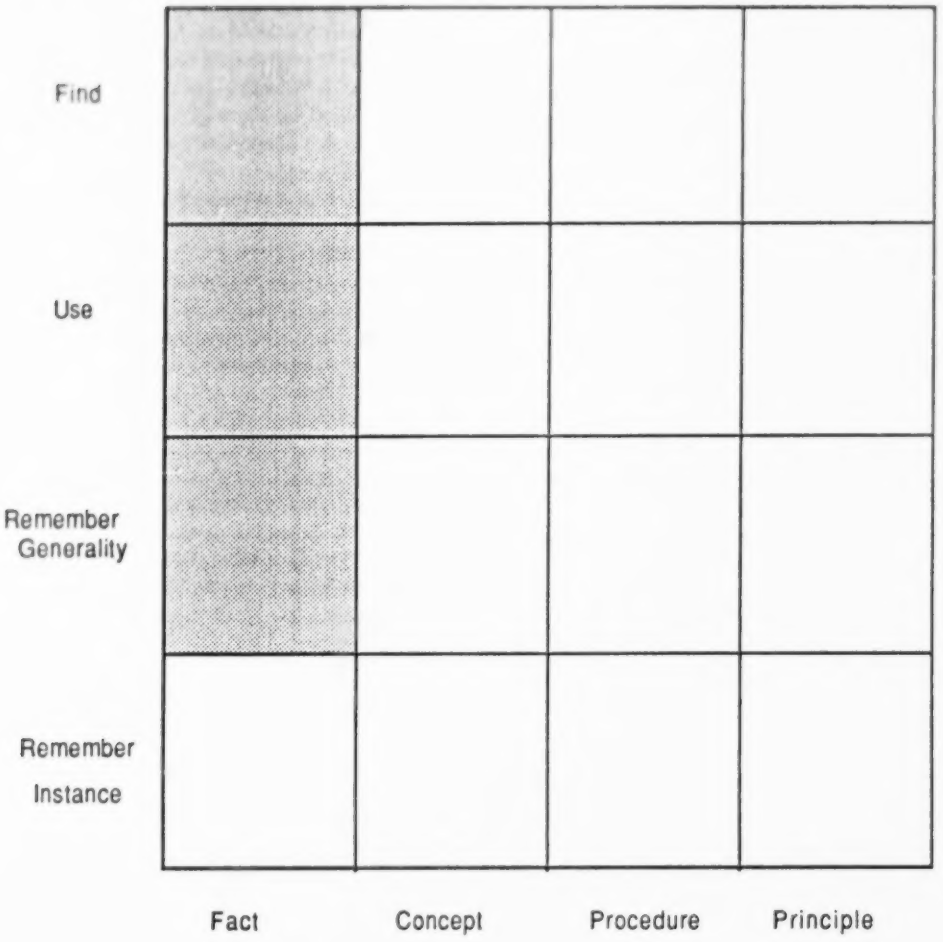

Figure 4. CDT performance/content matrix.

PERFORMANCE	PHASES OF INSTRUCTION		
	PRESENTATION	PRACTICE	PERFORMANCE
Find	None	legs.N, IG.N	legs.N, IG.N
Use	EG, Eegs	legs.N	legs.N
Remember Generality Paraphrase	EG, Eeg	legs.N	legs.N
Remember Generality Verbatim	EG	IG	IG
Remember Instance Paraphrase	Eeg	legs.r	legs.r
Remember Instance Verbatim	Eeg	leg	leg

Figure 5. Displays in Merrill's component display theory.

	Gagne	Merrill
Learning Outcomes	Five Categories (One-dimensional)	Performance/ Content Matrix (Two-dimensional)
Strategy	Nine Events of Instruction (Macro-strategy)	Primary and Secondary Presentation Forms (Micro-strategies)

Figure 6. Comparison of Gagné's and Merrill's theories.

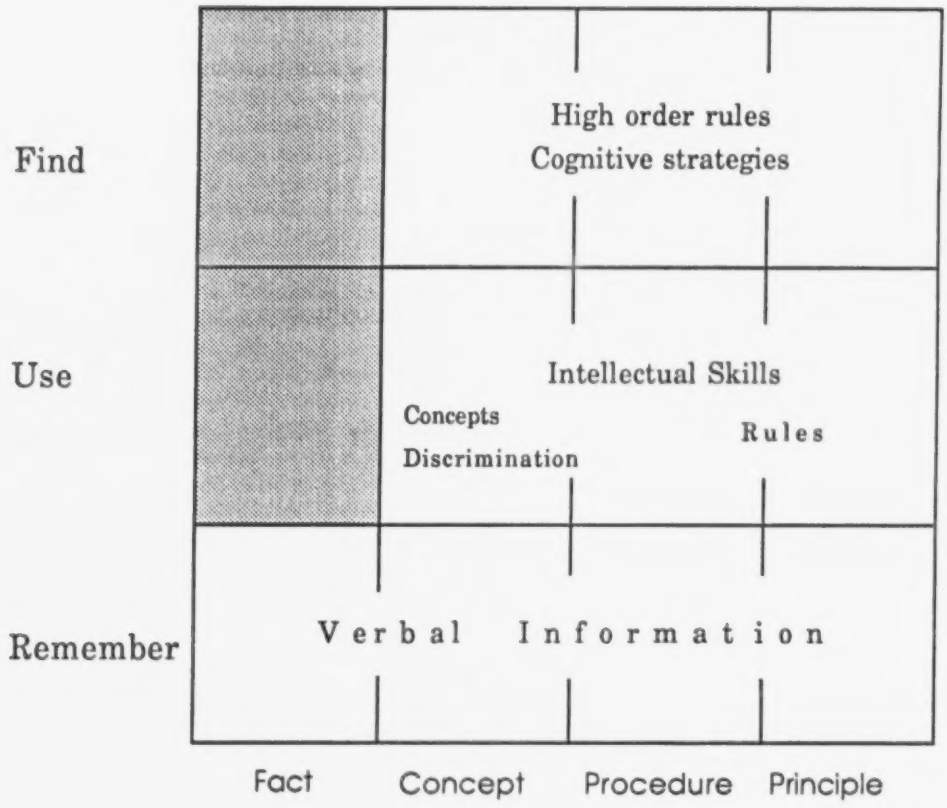

Figure 7. CDT performance/content matrix and Gagné's classification of learning outcomes.

Integrating Gagné and Merrill

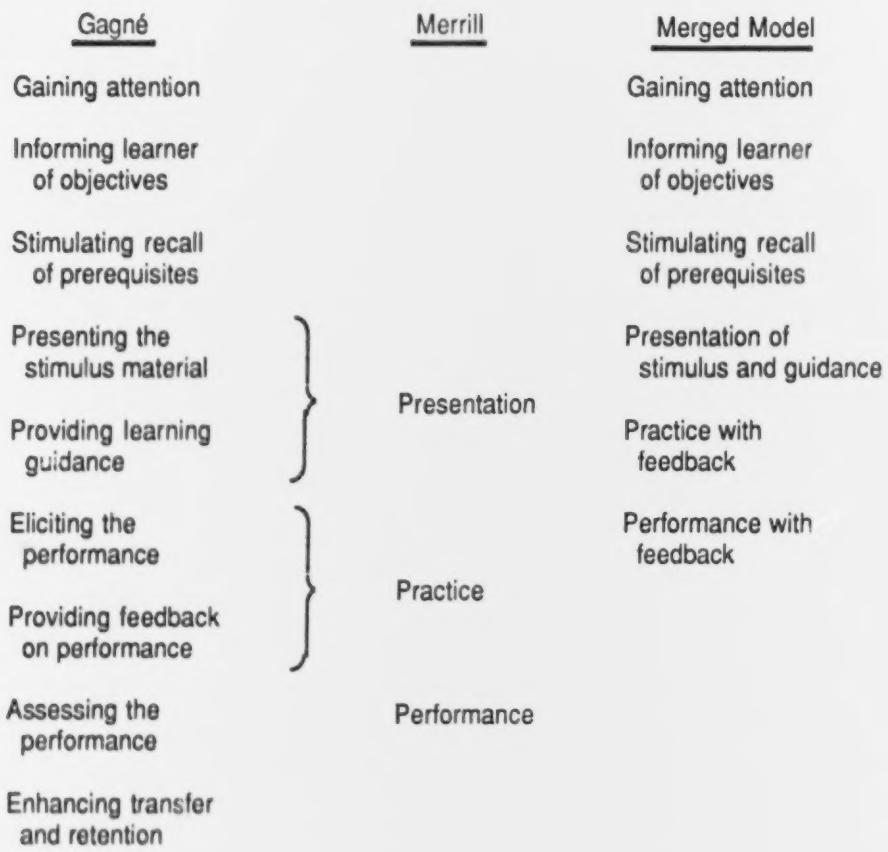

Figure 8. The integration of Gagné's and Merrill's strategies into a 6-step instructional design model.

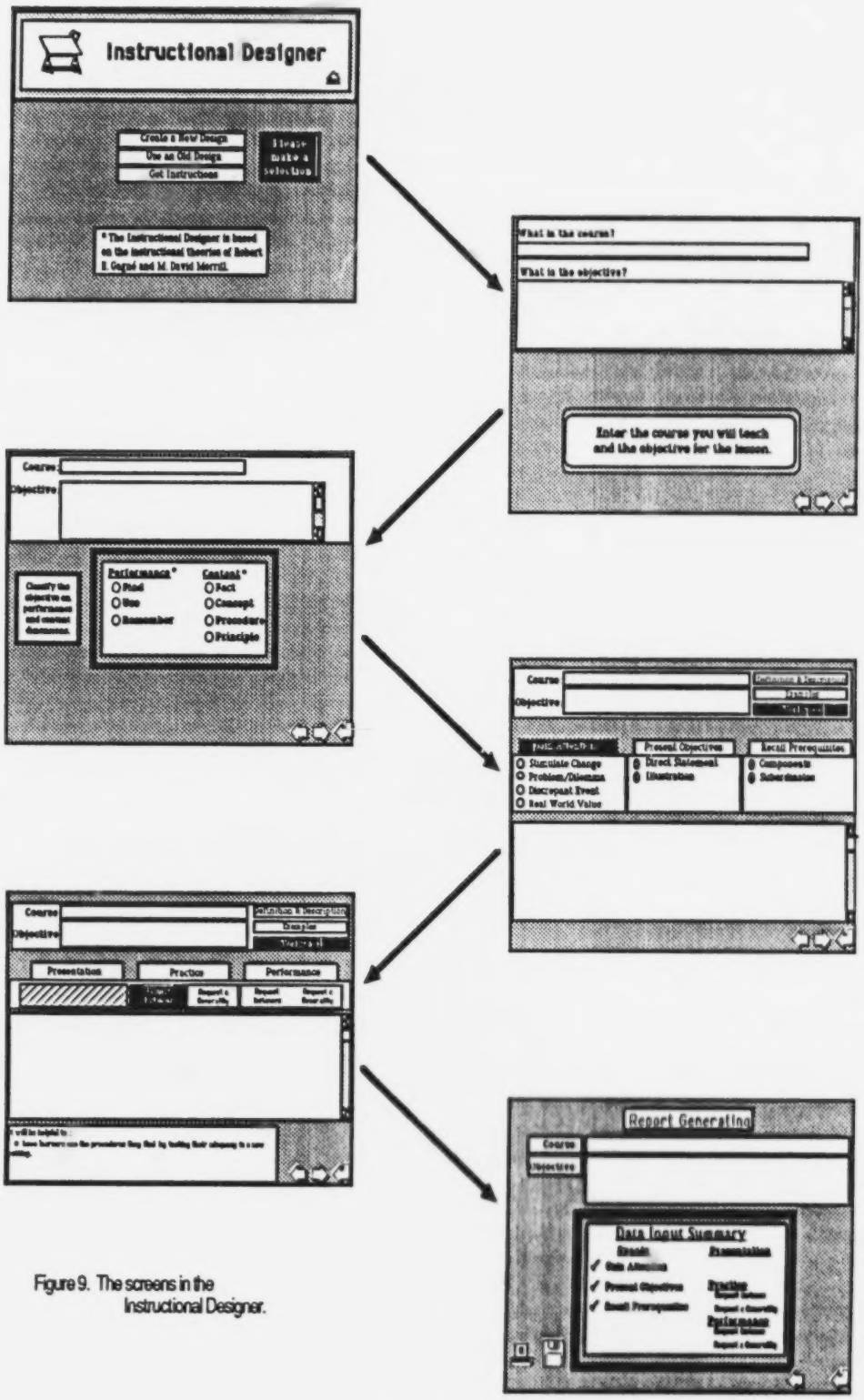

Figure 9. The screens in the Instructional Designer.

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APPENDIX

A Sample Design

COURSE: Spreadsheets

OBJECTIVE: Given access to a spreadsheet, identifies or writes the expressions to use for calculating sums, averages, minimums, or maximuns of specified cells, columns, or rows.

PERFORMANCE: Use

CONTENT: Procedure

•• Gain Attention ••

Show a spreadsheet with columns labeled "Total", "Maximum Sales", etc. and pose the question of how these values can be determined.

•• Present Objectives ••

Use direct statements to inform the learners that they will learn to

a. write expressions for determining cell values
b. prepare expressions using functions and formulas
c. identify appropriate and inappropriate expressions

•• Recall Prerequisites ••

The prerequisite skills that need to be recalled include --

a. order of arithmetic operations
b. specifying the location of any cell
c. specifying a range of cells
d. use of parenthese in arithmetic and algebraic expressions

•• Presentation ••

An arithmetic expression is used to calculate sums or averages of several cells. The procedure includes first specifying what function you want to perform followed by a designation of the cells you want the function performed on.

For example, to find the sum of the utility costs for the entire year, an expression using the word sum and designating the range of cells for January through December is needed. [@sum(C4...N4)]

Finding the maximum sales for an employee during the last week in June would be done by using the expression max and designating the range of cells for sales of all employees during the period.
[@max(H4...H13)]

•• Practice ••

Practice tasks will include the following --

a. finding the minimum and maximum sales during the year for any employee.
b. determining the total utilities costs for any designated month.
c. calculating the average monthly maintenance costs for the office equipment

Following each task, feedback will be given and a discussion of right and wrong responses.

•• Performance ••

Two tasks will be used to demonstrate achievement of the skills.

a. Write the expression to determine the average monthly sales for any designated salesperson.
b. Calculate the total sales for all salespersons during any designated period of the year.